Summer Dormancy and Survival of Tall Fescue in Relation to Endophyte Presence

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Introduction

True summer dormancy in temperate perennial grasses is the ability to survive summer stresses by ceasing growth and senescing vegetative tissues independently of water supply, as opposed to summer-active grasses, which respond to rains by continuing growth, but senesce during droughts (Volaire and Norton 2006). Summer dormancy is a common drought-escape mechanism for Mediterranean-origin perennial grasses, but is also being considered as a potentially useful trait in semiarid to humid zones whose climates are not strictly Mediterranean, but where temperate grass survival is threatened by summer heat and water deficits (Malinowski *et al*. 2005). Moreover, summer dormancy may provide a mechanism for adapting to climate change patterns that exacerbate summer stresses (West *et al*. 2009). Tall fescue [*Lolium arundinaceum* (Schreb.) S.J. Darbyshire] populations exhibit a range of summer dormancy potentials from nondormant (summer active) to varying levels of incomplete dormancy, but not complete dormancy (Norton *et al*. 2006). Summer drought survival of tall fescue is generally aided by symbiosis with a fungal endophyte [*Neotyphodium coenophialum* (Morgan-Jones & Gams) Glenn, Bacon & Hanlin comb.], and this endophyte is endemic in nearly all native populations of tall fescue (West 1994). Little is known of the influence of the endophyte on the expression of summer dormancy in their grass hosts or of the role of endophytes in host drought survival. We investigated the influence of environment and endophyte presence on expression of summer dormancy and survival in tall fescue in relation to expression of biochemical protectants.

Methods

Field plots were established in 2006 in a humid location (Fayetteville, Arkansas USA, 36.092 N, 94.170 W, mean rainfall 1169 mm) and a semiarid location (Vernon, Texas USA, 34.090 N, 99.365 W, mean rainfall 710 mm) under full irrigation or dryland. Three tall fescue types planted were 'Kentucky-31' (KY-31), 'Grasslands Flecha' (Flecha), and experiment line TX06V-B-FA (TX line), referred to herein as cultivars. KY-31 is a widely grown summer-active type, and the others are putative, incompletely summer-dormant types. Endophyte-infected and endophyte-free isopopulations of each cultivar were included in the test. Measurements included shoot dry matter production, shoot senescence, tiller-base water content, plant survival, superoxide dismutase (SOD) activity, and total free phenolic concentration.

Results

Growth of Flecha and TX line in Arkansas in mid-spring (May harvest) was greater than for KY-31 (Table 1). Growth in subsequent months was greater for KY-31 than for Flecha and TX line. The same trend occurred in the semiarid Texas location except that spring growth

Table 1. Forage dry matter yield without irrigation of tall fescue cultivars at Arkansas (humid) and Texas (semiarid) in 2008 averaged over endophyte levels and four replications.

Location	Cultivar	April	May	June	July	October
			---------- (kg/ha) ----------			
Arkansas	KY-31	20 a	2250 b	1720 a	280 a	1240 a
	Flecha	30 a	2610 ab	1620 b	180 b	1000 b
	TX line	30 a	2960 a	790 c	70 b	730 c
Texas	KY-31	2210 c	2740 a	2140 a	1620 a	770 c
	Flecha	2810 b	2150 b	1510 b	1200 b	1520 b
	TX line	2960 a	1920 b	1280 b	890 b	1780 a

Means within location and columns followed by unlike letters differ at $P < 0.05$

Table 2. Tiller-base water content, leaf senescence, superoxide dismutase activity, and total free phenolics (phenol equivalent) at Arkansas (humid) of dryland tall fescue cultivars differing in summer dormancy on 7 July 2007 averaged over endophyte levels and four replications.

Cultivar	Tiller-base water content	Leaf senescence	Superoxide dismutase	Total free phenolics
	(% of fresh wt.)	(% of dry wt.)	(units/mg protein)	(mg/g dry wt.)
KY-31	73 a	31 b	34 a	4.0 a
Flecha	61 b	52 a	16 b	2.8 b
TX line	60 c	45 a	13 b	3.1 b

Means within columns followed by unlike letters differ at $P < 0.05$.

peaked one month earlier, and KY-31 showed the least forage yield in autumn (October). The reason for the inferior autumn growth of KY-31 was that late-summer drought and heat caused high plant mortality, while Flecha and TX line survived. Flecha and TX line produced more harvestable forage than the summer-active KY-31 earlier in spring because of the summer-dormant types' habit of earlier stem elongation and flowering. Delayed peak flowering of KY-31 explained its superior yield over the summer-dormant types in the subsequent month. There were no consistent differences within cultivars for yield or time of flowering due to endophyte infection status.

Tiller-base water content was greater in KY-31 than the summer-dormant types in July 2007 (Table 2). Leaf senescence was greater in the summer-dormant fescues than in KY-31 (Table 2). These results are consistent with observations that summer dormancy in grasses is expressed by dehydration of the tiller base and greater leaf senescence relative to summer-active types (Volaire and Norton 2006). There were no differences in these measurements resulting from presence or absence of endophyte symbiosis (data not shown). Both indicators of biochemical protectant activity, SOD and total free phenolic production, were greater in KY-31 than in both the summer dormancy types (Table 2). This contravenes an hypothesis that these antioxidant agents may be involved in the superior survival of summer dormant grasses through a cellular protection mechanism. There was no endophyte effect on either of these measurements (data not shown).

Plant counts in nonirrigated plots at Arkansas in autumn of 2008 indicate that KY-31 exhibited 81% survival, whereas Flecha and TX line had 100% survival. Survival rates of all cultivars were unaffected by endophyte infection status. At the Texas location, survival of KY-31 averaged 74% at the beginning of summer of 2008, then declined to 37% by autumn, whereas plant survival of the summer-dormant cultivars was 98%. There was no advantage of endophyte infection in survival in any of the cultivars at Texas.

Conclusions

Plant survival after two summers of the partially summer-dormant cultivars, Flecha and TX line, was essentially perfect in both locations, even in the absence of irrigation and endophyte infection. The lack of an endophyte benefit in any measurement suggests that the dormancy trait is not conditioned by endophyte symbiosis, but rather the dormancy trait is controlled by plant genotype. The summer dormancy trait was more advantageous for use in the Southern Plains of Texas than in cooler, more humid Arkansas.

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